IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	
Saint-Hilaire et al.	Examiner: Knapp, Justin R.
Serial No. 09/989,136	Art Unit: 2182
Filed: November 20, 2001	
For: METHOD AND ARCHITECTURE TO SUPPORT INTERACTION BETWEEN A HOST COMPUTER AND REMOTE DEVICES	

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION PURSUANT TO 37 C.F.R.§1.131

Sir:

I, R. Alan Burnett, hereby declare that:

1. Intel Corporation of Santa Clara, California, is the assignee of the above-captioned patent application.

2. Intel Corporation hired the law firm for whom I work, Blakely, Sokoloff, Taylor, and Zafman (BSTZ), to prepare the above-caption patent application and represent the Inventors Ylian Saint-Hilaire and Jim W. Edwards before the USPTO.

3. I prepared the above-captioned patent application and the subject matter described and claimed therein.

4. On October 5, 2001, I conducted an invention disclosure meeting with Ylian Saint-Hilaire, and began preparing the above-captioned patent application. The application was based on information contained in the invention disclosure forms provided as Exhibit A, B, and C in the accompanying 37 C.F.R.§1.131 Declaration filed herewith, in combination with subject matter disclosed during the meeting.

5. I worked on preparing the patent application various days throughout the month of October, 2001.

6. On October 30, 2001, as evidenced by Exhibits D, E, and F, my legal assistant Jenny Miller submitted an Intel Patent Quality Review package, including a draft of the application specification and drawings and the Intel Patent Quality Review Checklist (IPQRC) to Intel for review. As per Intel procedures at the time of the filing of the application, an IPQRC package including a draft of the application was to be submitted for quality review prior to filing an application. As shown by the markups in Exhibit F (which identify differences between this draft and the filed application), the draft that was submitted was substantially identical to the filed application, absent some minor changes. The drawings were identical to those filed. (In order to not be duplicative, a copy of the drawings is not included in Exhibit F). Exhibit D is a note to the file used for the patent application to indicate when the IPQRC form submission was made, and was inserted into the file in accordance with BSTZ practice. Exhibit E is a copy of the cover page of the IPQRC.

7. As evidenced by the date written in Exhibit D, Intel approved the application for filing on November 15, 2001. Accordingly, formal papers, including an inventor's declaration/power of attorney and assignment documents were prepared and sent to Inventors Ylian Saint-Hilaire and Jim W. Edwards for signature. Upon receipt of the signed documents, the patent application was filed on November 20, 2001.

Rev. 15, 8/00

INTEL INVENTION DISCLOSURE

ATTORNEY-CLIENT PRIVILEGED COMMUNICATION
located at http://legal.intel.com

DATE: 06/19/01 20983 TRL Comm / IAG / TRL / CEL

It is important to provide accurate and detailed information on this form. The information will be used to evaluate your invention for possible filing as a patent application. When completed and signed, please return this form to the **Legal Department at JF3-147. You can submit electronically via e-mail to "invention disclosure submission" if all of the information is electronic, including drawings and supervisor approval.** If you have any questions, please call **264-0444.**

1. Inventor: Saint-Hilaire (Last Name) Ylian (First Name) _____ (Middle Initial)

Phone (503) 264-2188 M/S: JF1-273 Fax # (503) 264-1805

Citizenship: Canadian WWID: 10610963 Contractor: YES _____ NO X

Inventor E-Mail Address: ylian.saint-hilaire@intel.com

Home Address: 1316 NE Carlaby way #173

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***Corporate Level Group (e.g. iABG, NCG, CEG)** IAG **Division** TRL **Subdivision** CEL

Supervisor* Jim Edwards WWID 10065024 Phone (503) 264-8464 M/S: JF1-273

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Citizenship: US WWID: 10065024 Contractor: YES _____ NO X

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Supervisor* Mark Abel WWID 10059928 Phone (503) 264-8483 M/S: JF1-273

***If you are unsure of this information, please discuss with your manager.**

(PROVIDE SAME INFORMATION AS ABOVE FOR EACH ADDITIONAL INVENTOR)

2. Title of Invention: Remote PC Hosted devices

3. What technology/product/process (code name) does it relate to (be specific if you can):
Home Devices, home automation, PC in the Home, home adapter, home network.

4. Include several key words to describe the technology area of the invention in addition to # 3 above: Networks, wireless, Extended PC

5. Stage of development (i.e. % complete, simulations done, test chips if any, etc.): Concept

6. (a) Has a description of your invention been, or will it shortly be, published outside Intel:

NO: X YES: _____ If YES, was the manuscript submitted for pre-publication approval?

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(d) If the invention is embodied in a semiconductor device, actual or anticipated date of tapeout? _____

(e) If the invention is software, actual or anticipated date of any beta tests outside Intel: _____

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PLEASE READ AND FOLLOW THE DIRECTIONS ON HOW TO WRITE A DESCRIPTION OF YOUR INVENTION

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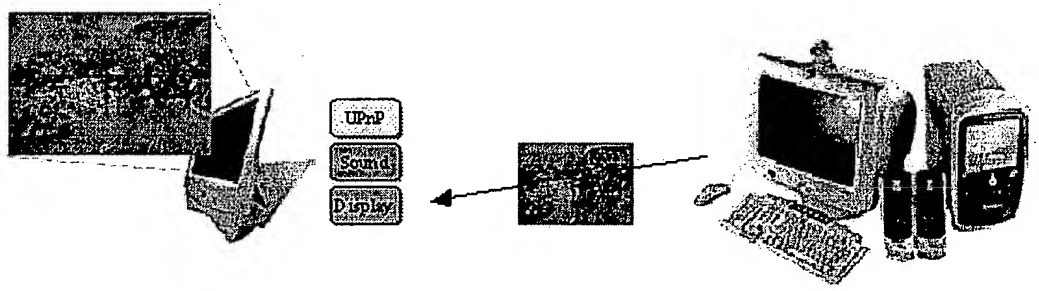


Picture Frame Extended PC

This invention describes a method by which a low-cost home appliance (or any device) would be built with minimal software and hardware. This device would be connected on the home network (or any network) and be completely driven by the PC.

Using this invention a picture frame device can be built with no storage and minimal memory (when compared to similar devices today). The computer in the home detects all such devices using UPnP (Universal Plug & Play) or another service discovery mechanism. Once the PC detects a device, it obtains (e.g. using UPnP) further information about the device and its capabilities.

The PC interacts with a device using a set of services offered by that device. These services may include "Remote Display", "Remote Audio", "Remote Input", "Remote Video", "Remote Software Update" and other services. Each service is discovered using UPnP or its equivalent. UPnP also provides a specific description on how to use the service.

Remote Display

This service would provide a simple TCP connection port on which the PC would send a stream of "Display this picture at position X,Y" type commands. Each of these commands makes the device overwrite its frame buffer with a new picture at the given position. The UPnP information

on this service would include the screen size, the color depth, the file formats supported and if synchronization is supported. The computer uses this information to process pictures to be in the format, color depth, and size (to prevent overflowing device's frame buffer) required for the device. The computer will also do any scaling needed (if a picture must be re-sized for a given device).

An optional synchronization service allows the computer to place time markers within the picture command stream. For example: if the computer must animate a small portion of the screen at 15 frames per seconds, the computer will insert time markers to indicate when this picture must be displayed. This allows the device to synchronize with its refresh rate and also eliminates network jitter that would cause the animation to be choppy. The display service sends back small messages indicating when it failed to meet the specified time requirements. This allows the PC to adapt the content to the device and network conditions.

Remote Audio

The UPnP description of this service includes the number of channels (speakers), the rate at which the device can play, the quality (number of bits) and supported sound formats (PCM for example). When applications running on the PC want to play sounds and music, the PC is responsible for mixing and converting this sound to a format the remote audio device will support.

In one implementation of this service, a TCP socket is opened to the remote audio device (port number given by the service's UPnP description). Both the device and PC TCP sockets can be optionally configured to buffer only a small amount of data (depending on sound quality, network latency and audio latency desired). The device simply reads PCM sound from the TCP socket and fills its sound buffer. If the device is unable to do so, it notifies the PC that there is a problem. The PC can adapt the sound quality to meet the device's performance or new network conditions.

Remote Input

The devices that can be built using this invention include many types of devices with input ranging from no input at all to pen-input, keyboard, mouse and buttons. UPnP is used to describe the existence of the input service. The information provided may include type of device, commands supported (buttons, positions (pen, mouse), clicks, wheel), etc

Some devices such as infrared remote controls might require code running on the PC to interpret the timing codes received and convert them to button push commands. The UPnP service might also be used in this case to advertise the presence of a custom input device and the URL link where the matching PC software required to support the device is located on the Internet. The PC can then automatically get and run this software (possibly signed, trusted software).

Other services such as Video, Software update, etc can be advertised and used in the same way. One of the most important points of this invention is that we are not defining a single "remoting" protocol, but rather a set of protocols, one for each service offered by the device. Each protocol is also defined to adapt to the specifics of the device. For example, some devices will play different audio formats at different rates; use different screen sizes at different color depths. The computer discovers this and adapts to it. This is also an important difference since, for example, current products require 640x480 display, mouse input at a minimum.

Technical Points

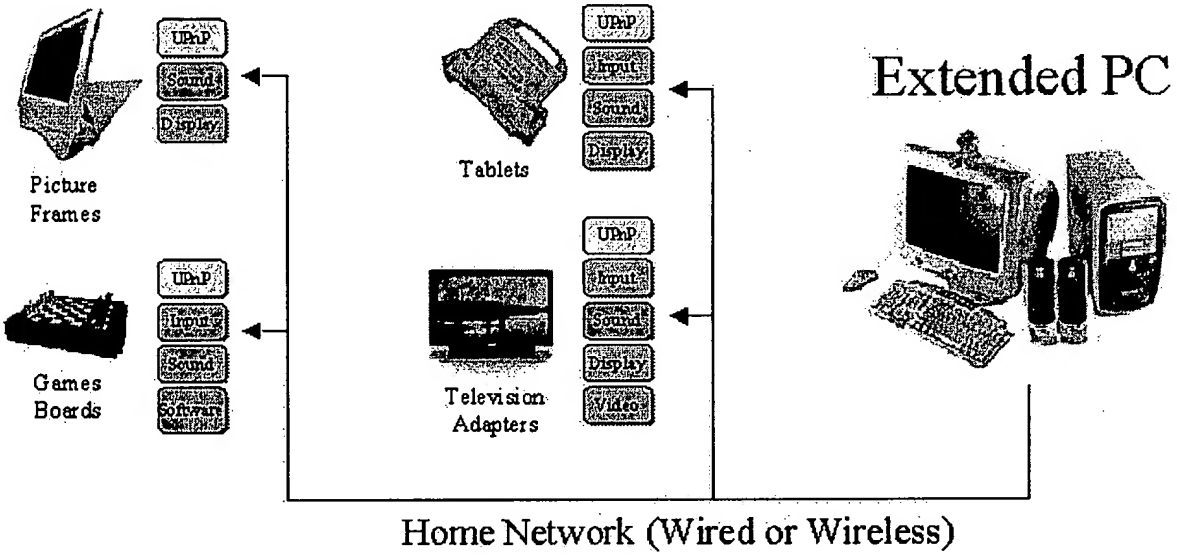
- The main goal and benefit is to drive much of the work that might be performed by a device onto the computer. This will result in cheaper devices.
- Each device may include one or more of the services described here. For example, some devices may not have an Input or a screen. This does not exclude them from using this invention. Each device advertises the services it has.

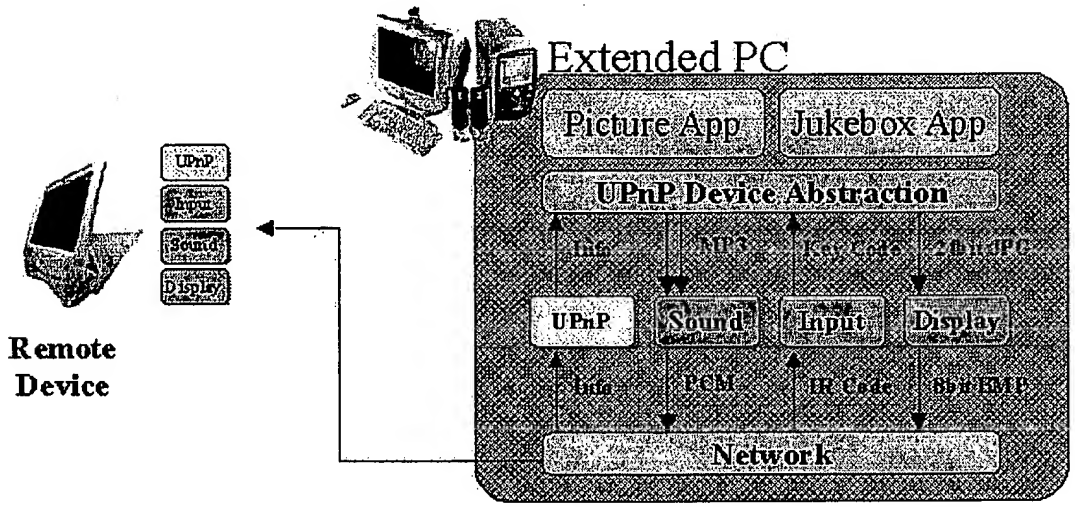
- The computer can drive many of these devices at the same time. Each device can be driven autonomously, but the computer can also create logical connections between the devices. For example a tablet device could be used as input to a picture frame device.

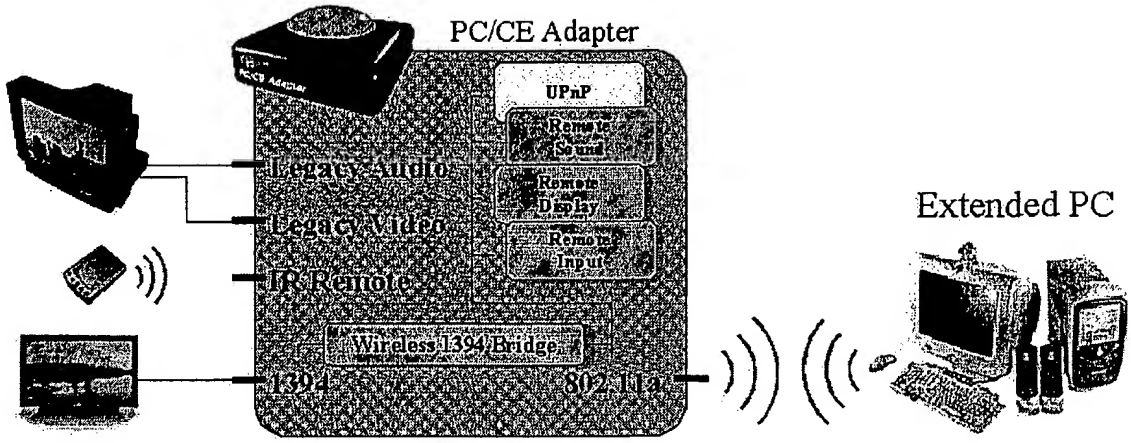
2. Describe advantage(s) of your invention over what is done now.

Currently, devices such as picture frames, tablets, setup boxes run fairly autonomously. With the existence of an always on, always connected Extended PC, these cheap devices can leverage the power of the PC to significantly lower their costs and make it possible to reuse existing capabilities provided by the PC which translates into lower TTM.

3. YOU MUST include at least one figure illustrating the invention. If the invention relates to software, include a flowchart or pseudo-code representation of the algorithm.







4. Value of your invention to Intel (how will it be used?).

The Extended PC strategy attempts to "make the PC relevant in the home", this is in the face of a growing lineup of products that run in the home without the involvement of the PC. This invention adds value to devices through the PC's inherent processing, storage, and connectivity capabilities and it also makes it possible to build cheaper devices. This invention will be used in a reference design for a PC/CE adapter that links the PC to the entertainment system in a family room.

5. Explain how your invention is novel. If the technology itself is not new, explain what makes it different.

Remote display techniques have been focused on optimizing bandwidth and on a pull model where clients connect to large servers that host applications. For example: remote administration of servers using dialup lines or the Internet, or remote online assistance thru the Internet. This invention is completely different in that the PC now hosts a portion of functionality the customer would otherwise have to buy within each device. It also uses a push model where the PC automatically discovers and pushes content to the devices.

One of the most important differences with things that are currently done in this space is the device capability discovery. Contrary to other "terminal" products, this invention discovers the devices capabilities at runtime. In the invention: a monitor, user input, audio playback are all optional components of a device. The computer discovers what services (display, audio...) the device offers and loads software that will take advantage of these services.

6. Identify the closest or most pertinent prior art that you are aware of.

While many remoting products exist: Windows Terminal Server, WinFrame, X-Windows, PC Anywhere, Carbon Copy... They don't use the same technology and are in a separate field of use. There is no known prior art in this space.

7. Who is likely to want to use this invention or infringe the patent if one is obtained and how would infringement be detected?

Devices that rely on the PC to be turned on to work might be potentially infringing on this invention. Discovery protocols such as UPnP are easy to examine using a network packet sniffer. Protocols such as UPnP can easily be probed to look at the services they offer and information given about each service. Network sniffers can also look at how the protocols are used with each service.

HAVE YOUR SUPERVISOR READ, DATE AND SIGN COMPLETED FORM OR FORWARD IT ELECTRONICALLY VIA E-MAIL TO INTENTION_DISCLOSURE_SUBMISSION

DATE: 4/27/01 SUPERVISOR: _____

BY THIS SIGNING, I (SUPERVISOR) ACKNOWLEDGE THAT I HAVE READ AND UNDERSTAND THIS DISCLOSURE, AND RECOMMEND THAT THE HONORARIUM BE PAID

Rev. 15, 8/00

INTEL INVENTION DISCLOSURE

ATTORNEY-CLIENT PRIVILEGED COMMUNICATION
located at http://legal.intel.com

20573

JUL 13 2001

DATE: 06/28/01 TRL Comm / IAG / TRL / CEL

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1. Inventor: Saint-Hilaire (Last Name) Ylian (First Name) _____ (Middle Initial)

Phone (503) 264-2188 M/S: JF1-273 Fax # (503) 264-1805

Citizenship: Canadian WWID: 10610963 Contractor: YES _____ NO X

Inventor E-Mail Address: ylian.saint-hilaire@intel.com

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City Hillsboro State OR Zip 97124 Country US

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Supervisor* Jim Edwards WWID 10065024 Phone (503) 264-8464 M/S: JF1-273

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(PROVIDE SAME INFORMATION AS ABOVE FOR EACH ADDITIONAL INVENTOR)

2. Title of Invention: Light Weight Remote Display & Synchronization

3. What technology/product/process (code name) does it relate to (be specific if you can):
Extended PC, Home Devices, PC in the Home, home adapter, home network, Display remoting.

4. Include several key words to describe the technology area of the invention in addition to # 3 above: Networks, wireless, Extended PC

5. Stage of development (i.e. % complete, simulations done, test chips if any, etc.): Concept

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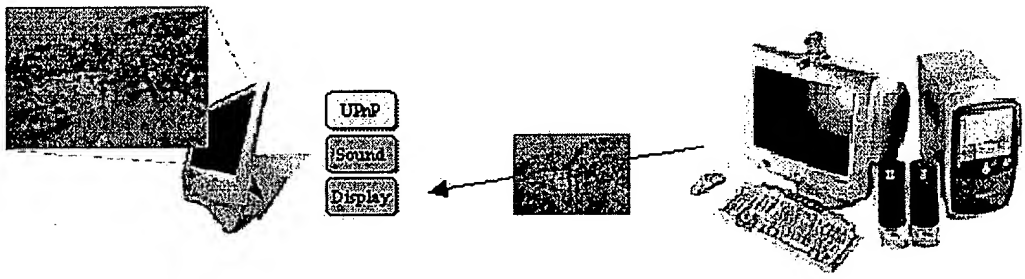

Picture Frame Extended PC

This invention describes a method for remoting a display to a low-cost networked home appliance (or any type of networked device with a display) that can be built with minimal software and hardware. This device can be connected anywhere on the home network (or any network) and be completely driven by the PC. Using this invention any PC application can display an interface on a remote device and synchronize small video and animations on the remote device.

Examples of display devices include a picture frame, a network tablet, an info terminal for kitchen management tasks, and a television display adapter, all of which are appropriately connected to the home network through a wired or wireless connection (e.g. 802.11a, 802.11b, Ethernet, HomeRF, HomePlug, 1394, etc.). Each of these devices advertises by some means the presence of a display on the network. A PC detects the presence of a display and sets up a data connection to the display.

Many of the devices as described above don't require large screen multimedia video but rather simple interaction with a user in order to accomplish specific tasks. For example, displaying pictures on a picture frame device only requires a simple user interface and simple images/animations (such as animated GIF's). In order to keep the device simple and as low cost as possible, the protocol used to talk to the device is kept very simple. In order to accomplish this goal, a basic set of primitives is supported. For example:

- **Reset** (int ProtocolVersion):
  - This primitive is used by the PC to reset the remote display. The display must clear itself and await instructions. This primitive also clears any state the device may have. The protocol is defined with minimal state, but reset is defined such as to future proof the device. If future protocol versions are defined, this command can be used to set which protocol version is going to be used by the PC.
- **Flush** (int TimeSinceLastSync)
  - Some display devices may support double buffering, where the device writes images to a hidden buffer and only displays the hidden buffer to the screen when asked to do so. Double buffering results in less display flicker. The "TimeSinceLastSync" parameter specifies the number of clock cycles to wait before issuing the Flush command.

    For example, suppose an NTSC TV adapter has double buffer support and it keeps track of the screen refresh (about 30 times per second). The device draws into its hidden buffer. When it receives a Flush(0) command, it displays the hidden buffer to the screen at the next screen refresh.

    If the PC wants to animate a GIF at 15 frames per seconds, it will need to send a animation frame to the device followed by a Flush(2) command. This will instruct the device to wait 2 refresh cycles before executing the Flush command.

    If an animation frame is not received in time due to network and device loads, another mechanism comes into play to allow a PC to adaptively recover: If more than 2 refresh cycles occur before the reception of the Flush(2) command, a FlushFailed() command is returned to the PC. This allows the PC to adapt the frame rate and animation size to better fit the current network load and ability of the device.
- **DrawFillBox** (x1, y1, x2, y2, Color)
  - Draw a fill box of the given color between the two point (x1,y2) and (x2,y2).
- **DrawImage** (x, y, image)
  - Draw an image at the (x1,x2) location. Here, the image can be in many different formats. When the PC discovers the device on the network, it must get the screen size, color depth and supported image formats. Information such as image width, height, and color are all encoded within the image format. The PC may use special features of some image types such as alpha-blending and transparency provided the device supports it.
- **PlaceVideoBox** (x1, y1, x2, y2)
  - In cases where the device supports streaming video as a separate service. This command allows the PC to place the video in a portion of the screen. Generally, the PC will set up the position of the video window and start streaming the video via a separate service.
- **Repaint** ( )
  - On occasion a device may lose the entire display content. To recover, the device can ask the PC to resend a complete update of the screen via the Repaint command.
- **FlushFailed** ( )
  - See Flush command. This command allows the PC to kept track of the quality of the animated output and adjust accordingly.

Technical Points

- Only Reset() and DrawImage() are required commands. All other commands are optional. The list of supported commands, display size, color depth and other information is given to the PC at discovery time. The PC must adapt to the restrictions of the device.
- Perfectly synchronized animations can be played on a device that supports the Flush() and FlushFailed() commands since the device animates the frames based on its own clock. If these commands are not available, the PC can still animate, but the quality of the animation is subject to network conditions.
- As defined, the Flush command synchronizes based on a device side clock. It is also possible to refine this command to also synchronize based on audio time stamps.
- Devices can also optionally support a Move() command that moves a block from a portion of the frame buffer to another. This allows for quick scrolling of graphics into the frame buffer.

2. Describe advantage(s) of your invention over what is done now.

Currently, devices such as picture frames, tablets, setup boxes run fairly autonomously. With the existence of an always-on, always-connected Extended PC, these devices can leverage the power of the Extended PC to significantly lower their costs and make it possible to reuse existing capabilities provided by the PC (which translates into lower TTM).

This invention provides an excellent, cost effective way of building a remote display of any kind. It is much lighter weight than similar "remote display" terminal software used on the PC. It also allows for synchronization of the frames to provide excellent visual quality for small animations and small video.

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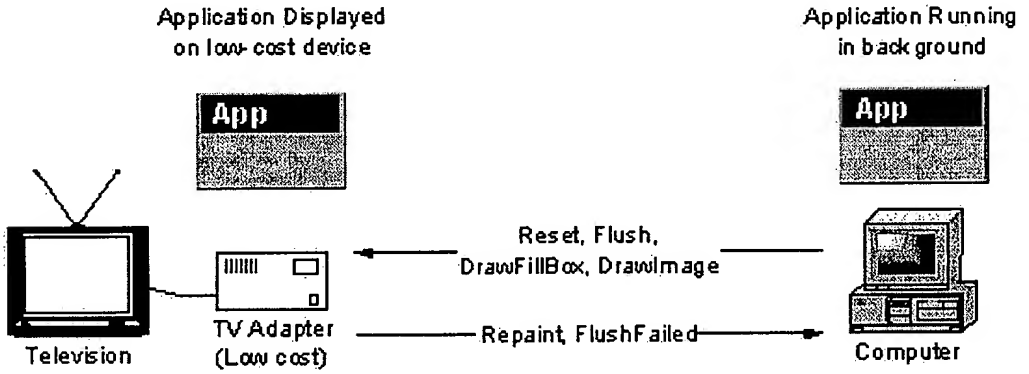

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7. Who is likely to want to use this invention or infringe the patent if one is obtained and how would infringement be detected?

Devices that rely on the PC to be turned on to work might be potentially infringing on this invention. Network sniffers can look at how the protocols are used with each service. Organizations that build low-cost devices that include a display with a PC-hosted user interface may infringe on the Invention. Analyzing the protocol used would detect the infringement.

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DATE: 7/11/01 SUPERVISOR: _____

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Rev. 15, 8/00

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Citizenship: Canadian WWID: 10610963 Contractor: YES _____ NO X

Inventor E-Mail Address: ylian.saint-hilaire@intel.com

Home Address: 1316 NE Carlaby way #173

City Hillsboro State OR Zip 97124 Country US

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Supervisor* Jim Edwards WWID 10065024 Phone (503) 264-8464 M/S: JF1-273

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(PROVIDE SAME INFORMATION AS ABOVE FOR EACH ADDITIONAL INVENTOR)

2. Title of Invention: Adaptive Remote Input Service

3. What technology/product/process (code name) does it relate to (be specific if you can):
Extended PC, Home Devices, PC in the Home, home adapter, home network, Display remoting, Input remoting

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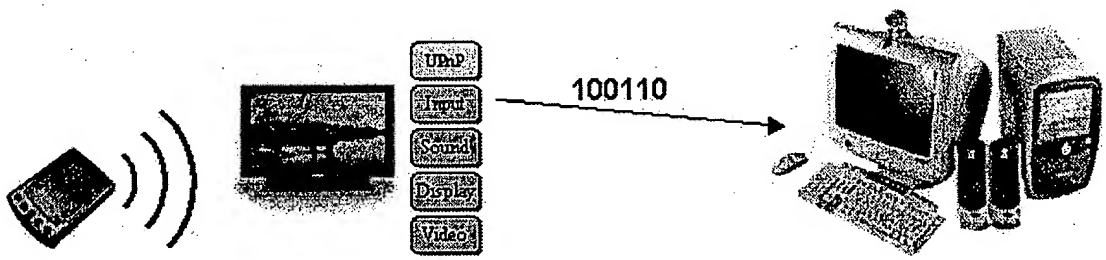


Television Adapter

Extended PC

This invention describes a method for remoting input from a low-cost networked home appliance (or any type of networked device with input) to a PC in such a way that the device can be built with minimal software and hardware. This device can be connected anywhere on the home network (or any network) and can be completely driven by the PC. Using this invention any device can send user input information to a PC that will interpret the user input and forward the command to the PC hosted device application.

Examples of input devices that can take advantage of this invention include picture frames, network tablets, information terminals, kitchen management devices and television display adapters, all of which are appropriately connected to the home network through a wired or wireless connection (e.g. 802.11a, 802.11b, HPNA, Ethernet, HomeRF, HomePlug, 1394, etc.). Each of these devices advertises by some means (UPnP for example) the presence of a user input source on the network. The discovery system (UPnP) also tells the PC of the type of user input that can be expected from the input source: remote control, keyboard, mouse/pen/touch or custom. A PC detects the presence of an input source and sets up a data connection to it. It then receives the user input and dispatches the user events to an application.

In some cases, the device will send custom input data, or in other words, raw data generated by the user input. This could include, for example, the length of IR pulses generated by a TV remote control. During the discovery process, the PC is informed of all of the custom input "channels"

that the device has. For each of these channels, the device informs the PC of where it can obtain a code module that can interpret the raw data. Giving the PC one or more URL's to the code module located on the Internet generally does this. The code is also identifies with a unique identification number, this allows the user to load the appropriate code module for a different source (Disk, CDROM) and have the PC associate the code module to the correct input source.

A basic set of primitives is supported by this lightweight remote input service. These primitives could include:

- **KeyDown** (int keydata)
- **KeyPress** (int keydata)
- **KeyUp** (int keydata)
  - The three keyboard primitives match the well-known keyboard events used is almost all operating systems. KeyDown and KeyUp occur whenever a key is pushed or released, this generally includes all keys including control keys such as shift, ctrl, alt and function keys. The KeyPress event contains the resulting interpretation of the keystrokes such as small and large capitalization and keyboard repetitions.
- **MouseDown** (int x, int y, int buttondata)
- **MouseMove** (int x, int y, int buttondata)
- **MouseUp** (int x, int y, int buttondata)
  - The three pointer primitives match the well-known keyboard events used is almost all operating systems. These primitives are not limited to mouse movements, any other pointing device such as trackballs, movement keys, pen input, touch sensitive screen and magnetic screens can also use them. During input service discovery, the PC is informed of the maximum values of x and y. If the device has a display, these pointer primitives may have a different resolution any may not match the x and y of the display. The PC could scale the pointer position to the display.
- **RemoteControlKey** (int buttondata)
  - The framework also use a remote control primitive to send to applications button information that is not generally associated with a computer keyboard. These buttons include: Play, Pause, Forward, Next Track, VCR, DVD... Some frameworks could opt to not use the primitive and map these remote control keys to standard computer keyboard events.
- **Custom** (int channel_number, byte[] custom_data)
  - All keyboard, mouse and possibly remote control primitives are dispatched to the applications as-is. For some devices, data processing must be done before a keyboard or mouse event can be generated. In order to lower the cost of the device, the device uses the custom primitive to send raw input data to the PC for interpretation. The PC than sends the raw data into the appropriate code module for interpretation, the code module will generally return mouse or keyboard primitives that can than by dispatched to the applications. Each channel number can contain completely different raw data that must be sent to a different code module for interpretation.

Technical Points

- A device does not have to use all of these primitives, it can use all or a subset of them. Some devices may opt to use only custom data as input.
- An XML file will describe how the input service behaves, what primates are used, that are the bounds of mouse coordinates, that custom channels exist and where to obtain the code modules to interpret the raw input data.
- The XML file is written by the manufacturer of the device and validated using a XML-Schema file (XSD file). The Extended PC can also use the XSD file to validate the devices XML file before it is parsed.
- The code modules that is loaded by the Extended PC to support one or more custom channel should be signed and authenticated if it is loaded from the Internet, just like any other code modules downloaded from the Internet.
- Custom input code modules should also be sand-boxed, in other words, prevented from tampering system the files and other software on the Extended PC. This provides an extra level of security.

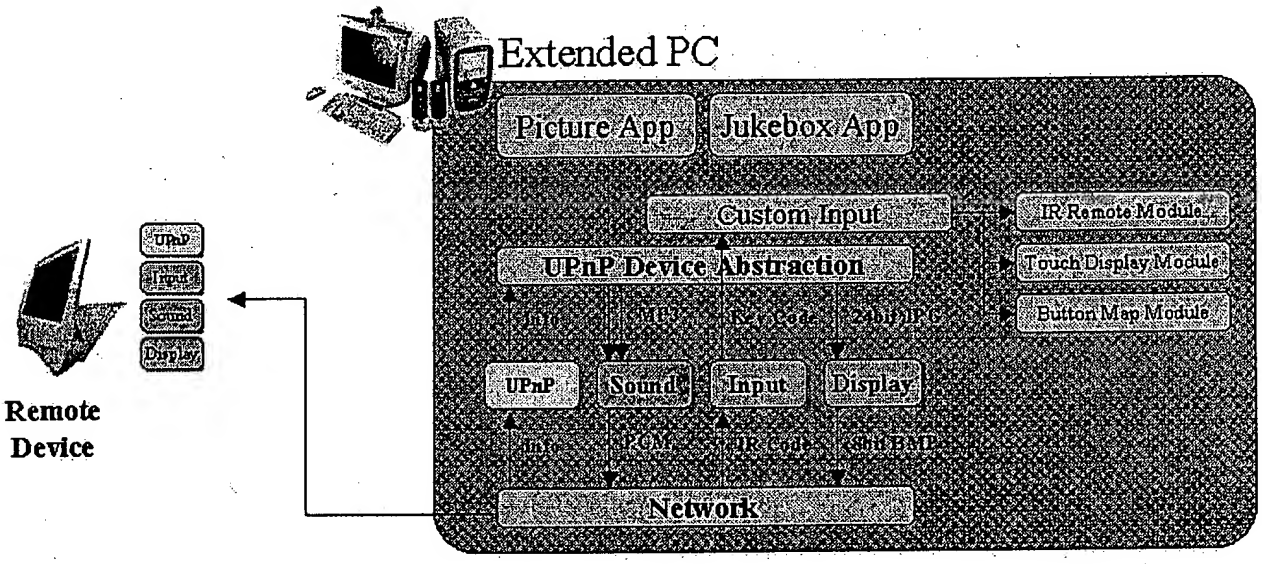
- One more instantiation of this service would do a similar operation in reverse. A code module on the PC could be loaded to generate a custom command to a device. For example, if a device has an IR transmitter, the PC could load a code module that sends a an array of IR pulse timings to the device to re-transmission.

2. Describe advantage(s) of your invention over what is done now.

Currently, devices such as picture frames, tablets, setup boxes run fairly autonomously. With the existence of an always-on, always-connected Extended PC, these devices can leverage the power of the Extended PC to significantly lower their costs and make it possible to reuse existing capabilities provided by the PC (which translates into lower TTM).

This invention provides an excellent, cost effective way of building remote devices of any kind and remote the input of such devices to the PC. It is built to take maximum advantage of the PC's flexibility and processing power while diminishing the cost of building the device.

3. YOU MUST include at least one figure illustrating the invention. If the invention relates to software, include a flowchart or pseudo-code representation of the algorithm.



4. Value of your invention to Intel (how will it be used?).

The Extended PC strategy attempts to "make the PC relevant in the home", in the face of a growing lineup of products that run in the home without the involvement of the PC. This invention adds value to devices through the PC's inherent processing, storage, and connectivity capabilities. It also makes it possible to build cheaper devices. This invention will be used in a reference design for a PC/CE adapter that links the PC to the entertainment system in a family room.

5. Explain how your invention is novel. If the technology itself is not new, explain what makes it different.

Most electronic devices in the home today are standalone, or connect to the PC using protocols that require the device to process user input, interpret the user's commands and act on them with the assistance of the PC. The invention is novel in that is pushes even more processing that would be otherwise done on the device to the PC and allows for lower cost devices.

6. Identify the closest or most pertinent prior art that you are aware of.

While many remoting products exist (e.g. Windows Terminal Server, WinFrame, X-Windows, PC Anywhere, Carbon Copy) they don't use the same approach convey user input to the user. Many solutions are targeted to WAN applications and fairly rich remote clients. There is no known prior art in this space.

7. Who is likely to want to use this invention or infringe the patent if one is obtained and how would infringement be detected?

Devices that rely on the PC to be turned on to host applications on behalf of a device might infringe on this invention. Network sniffers can look at how the protocols handle user input. Organizations that build low-cost devices that include remoting user input to a PC-hosted user interface may infringe on the Invention. Analyzing the protocol used would detect the infringement.

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File Number P12982 Intel QualRev Attorney _____

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Name of Law Firm BSTZ - Seattle

Status _____ Filing Date _____

Title: Method and Architecture to support interaction between a host computer and remote devices.

Inventors: Ylian Saint-Hilaire
Jim Edwards

PURPOSE

Your review of this application is intended to: (1) verify the quality of the patent applications being written for Intel, (2) provide valuable feed back to the author of this application to assist in his or her ability to write Intel applications of the highest quality, and (3) provide feedback to the Patent Prosecution Group which will pass on the general lessons learned from the review of this and other applications to all of those who are writing patent applications for Intel.

Instructions

To maintain consistency in the quality review process, please read these instructions and comply with each of the 5 required steps below.

1. **Check to see that you have been provided with the following:**
   - **complete application including drawings and claims**
   - **copy of "Instructions for Preparation and Prosecution of Intel Patent Application" (hereinafter "the Checklist") that was completed by the author of this application**

   If you are missing any items, please contact Jerry Miller **to request the missing portions.**

Attorney Docket: 042390.P12982

APPLICATION FOR UNITED STATES LETTERS OF PATENT

FOR

METHOD AND ARCHITECTURE TO SUPPORT INTERACTION BETWEEN A HOST COMPUTER AND REMOTE DEVICES

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Jenny E. Miller Date

METHOD AND ARCHITECTURE TO SUPPORT INTERACTION BETWEEN A HOST COMPUTER AND REMOTE DEVICES

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention concerns interaction with remote devices in general, and a method and system for performing remote interaction with low-resource devices, including display, playback and synchronization of multimedia content and receiving input from such devices.

2. Background Information

Today, there are several software tools that enable users to interact with a host computer from a remote location through software products running on both a remote computer and the host computer. These software products generally fall under the category of "remote control" software, and include such products as PC Anywhere, Carbon Copy, Windows Terminal Server, and RDP (remote desktop protocol)~~WinFrame~~ for Microsoft Windows operating system environments, and X-Windows for UNIX and LINUX environments.

As shown in FIGURE 1, these software products typically include a set of client-side software components 10 running on a remote computer 12 that interact with host-side software components 14 running on a host computer 16 via a communication link over a network 18. Notably, the client-side software components require both an operating system (OS) 20 and computer hardware resources components to enable the operating system to run, such as a high speed CPU 22 and memory 24. As a result, remote computer 12 requires both hardware and

software (i.e., the OS) components that are fairly expensive. Furthermore, much of the hardware and software components are duplicative when considering that similar hardware and OS software is required for host computer 16.

Recent advancements have also lead to the availability of standalone devices that are used for displaying and/or generating multimedia content. For example, digital picture frames are used to display one or more digital pictures that are stored on a memory media card; in order to change the pictures, the memory media card needs to be changed. Another common stand-alone device is the set-top box, which enables users to receive various multimedia content via a television network (e.g., cable or satellite network), and many models further enable users to access the Internet via a dial-up or cable link.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a schematic diagram illustrating a conventional architecture that enables a host computer to be accessed via a remote computer;

FIGURE 2 is a schematic diagram of an exemplary architecture that enables a host or "extended"~~an extended~~ PC to interact with various remote devices in accordance with the present invention;

FIGURE 3 is a schematic diagram illustrating exemplary host-side and client-side software components to enable an extended PC to interact with a remote device;

FIGURE 4 is a flowchart illustrating operations that are performed to enable interaction between a host computer and a remote device;

FIGURE 5 is a schematic diagram illustrating a plurality of Universal Plug and Play (UPnP)-enabled devices, embedded devices, services, and control points for explaining a typical UPnP environment

FIGURE 6 is a block schematic diagram illustrating UPnP device and service advertisement and control point search mechanisms;

FIGURE 7 comprises a set of three tables presenting tabular information pertaining to discovery messages broadcast during a UPnP discovery step;

FIGURE 8 is a block schematic diagram illustrating how description information is retrieved during a UPnP description step;

FIGURE 9 is a schematic block diagram illustrating an exemplary architecture in accordance with the invention that enables a host computer to display content on a remote device;

FIGURE 10 is a schematic block diagram illustrating an exemplary architecture in accordance with the invention that enables a host computer to send audio content to a remote device and have the audio content played back by the remote device;

FIGURE 11 is a schematic block diagram illustrating an exemplary architecture in accordance with the invention that enables various input devices operatively coupled to a remote device to provide input to a host computer;

FIGURE 12 is a schematic block diagram illustrating an exemplary architecture corresponding to a PC/CE adapter that enables an extended PC to push display and audio content to devices connected to the PC/CE adapter; and

FIGURE 13 is a schematic diagram illustrating a personal computer that may be used for an extended PC in accordance with the invention.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

A system and method for displaying interacting with remote devices via an extended PC host is described in detail herein. In the following description, numerous specific details are provided, such as exemplary service protocols and system architectures, to provide a thorough understanding of embodiments of the invention. One skilled in the relevant art will recognize, however, that the invention can be practiced without one or more of the specific details, or with other methods, components, etc. In other instances, well-known structures or operations are not shown or described in detail to avoid obscuring aspects of various embodiments of the invention.

Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, the appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

The present invention provides a mechanism that enables interaction between a low-cost networked device (i.e., the remote device) and an "extended" personal computer, wherein a majority of the software and hardware components used to enable the interaction are provided by the extended PC, and the remote device requires limited hardware that supports "lightweight" software service components. The extended PC, which is also referred to as a "host" PC herein, is termed "extended" because it extends the reach of a PC in a home environment.

As shown in FIGURE 2, the present invention enables interaction between a plurality of remote devices, including digital picture frames 30, electronic game boards 32, digital network tables 34 and television adapters 36, and an "extended" personal computer (PC) 38 (also referred to as the "host" or "host computer") via a network 40. In addition to the devices shown herein, the remote devices may include any device capable of hosting a network connection, including information terminals and kitchen management devices. Typically, network 40 may comprise a wired or wireless network, such as networks based on the 802.11a, 802.11b, HPNA, Ethernet, HomeRF, HomePlug, IEEE 1394 (Firewire), etc, standards, or hybrid networks that use two or more of these network standards. Generally, the interactions between a remote device and an extended PC are enabled by host-side software components 42 running on extended PC 38 and a set of software service components running on the remote device. Exemplary software services components are enabled, in part, by Universal Plug and Play (UPnP) modules 44, and include sound service modules 46, display service modules 48, input service modules 50 and video service modules 52.

An exemplary software architecture that facilitates interaction with a digital network tablet~~, such as Intel's Web tablet,~~ is shown in FIGURE 3. The architecture includes host-side software components 54 that interact with client-side components 56. The host-side software components include a picture application 58, a jukebox application 60, a UPnP device abstraction layer 62, a UPnP module 64, a sound module 66, an input module 68, a display module 70, and a network interface module 72. The client-side software services include a UPnP module 40, an input service module 50, a sound service module 46, and display service module 48.

A flowchart corresponding to a general high-level use-case of the invention is shown in FIGURE 4. In order to enable uni- and bi-directional interactions with remote devices, there needs to be a mechanism to establish network communication between the extended PC and each remote device. As explained below in further detail, this process begins in a block 80 by allocating an IP address for the device, and then using a discovery mechanism that enables devices connected to an appropriate network to be "discovered" in a block 81. After the device has been discovered, description information pertaining to the capabilities of the device and services provided by the device are retrieved in a block 82. Using connectivity data provided by this information, a network communication link is established between the extended PC and the remote device in a block 83.

In general, each device will provide one or more services that may be requested to be performed by other devices on the network. These services may typically include "remote display," "remote audio," "remote input," "remote video," and other similar services. Typically, each service will be designed to interact with a corresponding service component (e.g., software module) running on extended PC 38. For example, for each client-side software service module shown in FIGURE 3, there is a corresponding host-side software component running on extended PC 38.

Each of the software components running on extended PC 38 comprise one or more software modules that are specifically-tailored to interact with a corresponding remote device service using a particular service protocol. Depending on the services supported by a given host, corresponding host-side modules and protocols will be selectively loaded and enabled for execution on extended PC 38 in a block 84. Interaction between the host and client devices will then be performed using appropriate service protocols in a block 85.

Establishing Network Connection, Discovery and Retrieving Capabilities using UPnP

In one embodiment, establishing network communication, discovery of devices, and retrieval of those devices' capabilities and services is enabled through Universal Plug and Play. UPnP is an architecture for pervasive peer-to-peer network connectivity that enables network communication between UPnP-enabled devices using zero-configuration, "invisible" networking. Through UPnP, a device can dynamically join a network, obtain an IP address, convey its capabilities, and learn about the presence and capabilities of other devices sharing the network. UPnP leverages Internet components, including IP, TCP, UDP, HTTP, and XML. Like the Internet, contracts are based on wire protocols that are declarative, expressed in XML, and communicated via HTTP. Furthermore, UPnP networking is media independent, does not require device drivers, and can be implemented using any programming language on any operating system.

The basic building blocks of UPnP networks are *devices*, *services* and *control points*. As shown in FIGURE 5, each UPnP-enabled *device* comprises a container of one or more services and optional nested (i.e., embedded) devices and services. For instance, a UPnP device 90 comprises a single device 92 that provides two services 94 and 96, while a UPnP device 98 comprises a single device 100 that provides a service 102, and a UPnP device 104 that includes a root device 106 that provides a service 108 and an embedded device 110 providing services 112 and 114. Different categories of UPnP devices will be associated with different sets of services and embedded devices. Information identifying a given device, its services, and any embedded devices and their services are provided by an XML description document that is hosted by that device.

The smallest unit of control in a UPnP network is a *service*. A service exposes actions and models its state with state variables. For instance, a clock

service could be modeled as having a state variable, current_time, which defines the state of the clock, and two actions, set_time and get_time, which allow control of the service. Similar to the device description, service information is part of an XML service description standardized by the UPnP forum. A pointer (URL) to these service descriptions is contained within the device description document.

A control point in a UPnP network is a controller capable of discovering and controlling other devices. For example, as shown in FIGURE 5, control points include devices used (e.g., solely) to control other devices, as depicted by a control point 114~~point 116~~ (e.g., extended PC 38), as well as controllers within devices that may be both controlled by other devices, as depicted by a control point 116.~~point 118.~~ After discovery, a control point may: retrieve the device description and get a list of associated services; retrieve service descriptions for interesting services; invoke actions to control the service; and/or subscribe to the service's event source.

Addressing

The foundation for UPnP networking is IP *addressing*, which comprises "step 0" in UPnP networking. In one embodiment, each device provides a Dynamic Host Configuration Protocol (DHCP) client that searches for a DHCP server when the device is first connected to the network. If a DHCP server is available (i.e., a managed network exists), the device will use the IP address assigned to it by the DHCP server. If no DHCP server is available (i.e., the network is unmanaged), the device must use automatic IP addressing (Auto-IP) to obtain an address. In brief, Auto IP defines how a device intelligently chooses an IP address from a set of reserved addresses and is able to move easily between managed and unmanaged networks. If during the DHCP transaction, the device obtains a domain name, e.g.,

through a DNS server or via DNS forwarding, the device should use that name in subsequent network operations; otherwise, the device should use its IP address.

A device that supports AUTO-IP and is configured for dynamic address assignment begins by requesting an IP address via DHCP by sending out a DHCPDISCOVER message. The amount of time this DHCP Client should listen for DHCPOFFERS is implementation dependent. If a DHCPOFFER is received during this time, the device will continue the process of dynamic address assignment. If no valid DHCPOFFERS are received, the device may then auto-configure an IP address. To auto-configure an IP address using Auto-IP, the device uses an implementation-dependent algorithm for choosing an address in the 169.254/16 range. The first and last 256 addresses in this range are reserved and should not be used. The selected address should then be tested to determine if the address is already in use. If the address is in use by another device, another address must be chosen and tested, up to an implementation-dependent number of retries. Preferably, the address selection should be randomized to avoid collision when multiple devices are attempting to allocate addresses.

Once a device has a valid IP address for the network, it can be located and referenced on that network through that address. There may be situations where an end user (e.g., a user of extended PC) needs to locate and identify a device. In these situations, a friendly name for the device is much easier for a human to use than an IP address. Moreover, names are much more static than IP addresses. Clients that refer to a device by name don't need to be modified when IP address of a device changes. Mapping of the device's DNS name to its IP address could be manually entered into DNS database or dynamically configured, if such a facility is provided by the extended PC. While computers and devices supporting dynamic

DNS updates can register their DNS records directly in DNS, it is also possible to configure a DHCP server to register DNS records on behalf of these DHCP clients.

Discovery

Once an IP address is obtained, *discovery* (UPnP networking "step 1") may be performed. When a device is added to the network, the UPnP discovery protocol allows that device to advertise its services to control points on the network, as shown in FIGURE 6. Control points can also discover services. When a control point is added to the network, the UPnP discovery protocol allows that control point to search for devices of interest on the network. The fundamental exchange in both cases is a discovery message containing a few, essential specifics about the device or one of its services, e.g., its type, identifier, and a pointer to more detailed information.

The UPnP discovery protocol is based on the Simple Service Discovery Protocol (SSDP). SSDP defines how network services can be discovered on the network. SDDP is built on HTTPU and HTTPMU (variants of HTTP defined to deliver messages on top of UDP/IP instead of TCP/IP) and defines methods both for a control point to locate resources of interest on the network, and for devices to announce their availability on the network.

When a device is added to the network, it multicasts discovery messages to advertise its root device, any embedded devices, and its services. Each discovery message contains four major components:

1. A potential search target (e.g., device type), sent in an NT header;
2. A composite identifier for the advertisement, sent in a USN header;
3. A URL for more information about the device (or enclosing device in the case of a service), sent in a LOCATION header; and

4. A duration for which the advertisement is valid, sent in a CACHE-CONTROL header.

To advertise its capabilities, a device multicasts a number of discovery messages. With reference to FIGURE 6, a root device will multicast three discovery messages 120 for the root device, two discovery messages 122 for each embedded device, and one discovery message 124 for each service. The content of these messages are shown in FIGURE 7.

When a device is added to the network, it must send a multicast request with method NOTIFY and ssdp:alive in the NTS header in the following format, wherein values in *italics* are placeholders for actual values:

```
NOTIFY * HTTP/1.1
HOST: 239.255.255.250:1900
CACHE-CONTROL: max-age = seconds until advertisement expires
LOCATION: URL for UPnP description for root device
NT: search target
NTS: ssdp:alive
SERVER: OS/version UPnP/1.0 product/version
USN: advertisement UUID
```

The line `HOST: 239.255.255.250:1900` specifies the multicast channel and port reserved for SSDP by the Internet Assigned Numbers Authority. The CACHE-CONTROL value specifies a duration during which the advertisement is valid.

When a device and its services are going to be removed from the network, the device should multicast a ssdp:byebye message corresponding to each of the ssdp:alive messages it multicasted that have not already expired. The following format is used for each message, wherein placeholders for actual values are in *italics*:

```
NOTIFY * HTTP/1.1
HOST: 239.255.255.250:1900
NT: search target
NTS: ssdp:byebye
USN: advertisement UUID
```

When a control point is added to the network, the UPnP discovery protocol allows that control point to search for devices of interest on the network. It does this by multicasting a search message 126 with a pattern, or target, equal to a type or identifier for a device or service, as shown in FIGURE 6. Responses 128 from devices that respond to the search message contain discovery messages essentially identical to those advertised by newly connected devices, which are unicast.

The multicast request is made with method M-SEARCH in the following format, wherein placeholders for actual values are in *italics*:

```
M-SEARCH * HTTP/1.1
HOST: 239.255.255.250:1900
MAN: "ssdp:discover"
MX:  seconds to delay response
ST:  search target
```

The ST: value must be in one of the following formats:

`ssdp:all`
Search for all devices and services.

`upnp:rootdevice`
Search for root devices only.

`uuid:`*`device-UUID`*
Search for a particular device. Device UUID specified by UPnP vendor.

`urn:schemas-upnp-org:device:`*`deviceType:v`*
Search for any device of this type. Device type and version defined by UPnP Forum working committee.

`urn:schemas-upnp-org:service:`*`serviceType:v`*
Search for any service of this type. Service type and version defined by UPnP Forum working committee.

To be found, a device must send a response to the source IP address and port that sent the request to the multicast channel. Responses to M-SEARCH are intentionally parallel to advertisements, and as such, follow the same pattern as listed for NOTIFY with ssdp:alive discussed above, except that the NT header is replaced with an ST header. The response is sent in the following format, wherein placeholders for actual values are in *italics*:

```
HTTP/1.1 200 OK
CACHE-CONTROL: max-age = seconds until advertisement expires
DATA: when response was generated
EXT:
LOCATION:  URL for UPnP description for root device
SERVER:  OS/version UPnP/1.0 product/version
ST:  search target
USN:  advertisement UUID
```

If the ST header in the request was:

`ssdp:all`
Respond 3 + 2d + k times for a root device with d embedded devices and s embedded services but only k distinct service types. Value for ST header must be the same as the NT header in NOTIFY messages with ssdp:alive. Single URI.

`upnp:rootdevice`
Respond once for root device. Must be `upnp:rootdevice`. Single URI

`uuid:`*device-UUID*
Respond once for each device, root or embedded. Must be uuid:*device-UUID*. Device UUID specified by UPnP vendor. Single URI.

`urn:schemas-upnp-org:device:`*deviceType*`:v`
Response once for each device, root or embedded. Must be in the form of `urn:schemas-upnp-org:device:`*deviceType*`:v`. Device type and version defined by UPnP Forum working committee.

`urn:schemas-upnp-org:service:`*serviceType*`:v`
Response once for each device, root or embedded. Must be in the form of `urn:schemas-upnp-org:service:`*serviceType*`:v`. Service type and version defined by UPnP Forum working committee.

Description

The next step (2) in UPnP networking is *description*. After a control point has discovered a device, the control point still knows very little about the device. For the control point to learn more about the device and its capabilities, or to interact with the device, the control point must retrieve the device's description from the URL provided by the device in the discovery message. Devices may contain other, logical devices, as well as functional units, or *services*. The UPnP description for a device is expressed in XML and typically includes vendor-specific, manufacturer information like the model name and number, serial number, manufacturer name,

URLs to vendor-specific Web sites, etc. The description also includes a list of any embedded devices or services, as well as URLs for control, eventing, and presentation. For each service, the description includes a list of the commands, or *actions*, the service responds to, and parameters, or *arguments*, for each action; the description for a service also includes a list of variables; these variables model the state of the service at run time, and are described in terms of their data type, range, and event characteristics.

The UPnP description for a device is partitioned into two, logical parts: a *device description* describing the physical and logical containers, and one or more *service descriptions* describing the capabilities exposed by the device. A UPnP device description includes vendor-specific, manufacturer information like the model name and number, serial number, manufacturer name, URLs to vendor-specific Web sites, etc. (details below). For each service included in the device, the device description lists the service type, name, a URL for a service description, a URL for control, and a URL for eventing. A device description also includes a description of all embedded devices and a URL for presentation of the aggregate.

Note that a single physical device may include multiple logical devices. Multiple logical devices can be modeled as a single root device with embedded devices (and services), as shown in FIGURE 8, or as multiple root devices (perhaps with no embedded devices). In the former case, there is one UPnP device description for the root device, and that device description contains a description for all embedded devices. In the latter case, there are multiple UPnP device descriptions, one for each root device.

A UPnP device description is written in XML syntax and is usually based on a standard UPnP Device Template. A UPnP service description includes a list of commands, or *actions*, the service responds to, and parameters, or *arguments*, for

each action. A service description also includes a list of variables. These variables model the state of the service at run time, and are described in terms of their data type, range, and event characteristics. This section explains the description of actions, arguments, state variables, and the properties of those variables.

Like a UPnP device description, a UPnP service description is written in XML syntax and is usually based on a standard UPnP Service Template. UPnP vendors can differentiate their devices by extending services, including additional UPnP services, or embedding additional devices. When a control point retrieves a particular device's description, these added features are exposed to the control point. The device and service descriptions authoritatively document the implementation of the device.

Retrieving a UPnP device description is relatively simple: the control point issues an HTTP GET request on the URL in the discovery message, and the device returns the device description. Retrieving a UPnP service description is a similar process that uses a URL within the device description. The protocol stack, method, headers, and body for the response and request are explained in detail below.

As long as the discovery advertisements from a device have not expired, a control point may assume that the device and its services are available. The device and service descriptions may be retrieved at any point since the device and service descriptions are static as long as the device and its services are available. If a device cancels its advertisements, a control point should assume the device and its services are no longer available.

The UPnP description for a device contains several pieces of vendor-specific information, definitions of all embedded devices, URL for presentation of the device, and listings for all services, including URLs for control and eventing. In addition to defining non-standard devices, UPnP vendors may add embedded devices and

services to standard devices. To illustrate these, below is a listing with placeholders in *italics* for actual elements and values corresponding to a device description.

```
<?xml version="1.0"?>
<root xmlns="urn:schemas-upnp-org:device-1-0">
   <specVersion>
      <minor>1</major>
      <minor>0</minor>
   </specVersion>
   <URLBase>base URL for all relative URLs</URLBase>
   <device>
      <deviceType>urn:schemas-upnp-org:device:deviceType:v</deviceType>
      <friendlyName>short user-friendly title</freindlyName>
      <manufacturer>manufacturer name</manufacturer>
      <manufacturerURL>URL to manufacturer site</manufacturerURL>
      <modelDescription>long user-friendly title</modelDescription>
      <modelName>model name</modelName>
      <modelNumber>model number</modelNumber>
      <modelURL>URL to model site</modelURL>
      <serialNumber>manufacturer's serial number</serialNumber>
      <UDN>uuid:UUID</UDN>
      <UPC>Universal Product Code</UPC>
      <iconList>
         <icon>
            <mimetype>image/format</mimetype>
            <width>horizontal pixels</width>
            <height>vertical pixels</height>
            <depth>color depth</depth>
            <url>URL to icon</url>
         </icon>
         XML to declare other icons, if any, go here
      </iconList>
      <serviceList>
         <service>
            <serviceType>urn:schemas-upnp-org:service:
            serviceType:v</serviceType>
            <serviceId>urn:upnp-org:serviceId:serviceId</serviceId>
            <SCPDURL>URL for control</controlURL>
            <controlURL>URL for eventing</eventSubURL>
         </service>
            Declarations for other services defined by a UPnP Forum working
            committee (if any) go here
            Declarations for other services added by UPnP vendor (if any)
            go here
      </serviceList>
      <deviceList>
         Description of embedded devices defined by a UPnP Forum
         working committee (if any) go here
         Description of embedded devices added by UPnP vendor (if any)
         go here
      </deviceList>
      <presentationURL>URL for presentation</presentationURL>
   </device>
</root>
```

The UPnP description for a service defines actions and their arguments, and state variables and their data type, range, and event characteristics. Each service may have zero or more actions, while each action may have zero or more arguments. Any combination of these arguments may be input or output parameters. If an action has one or more output arguments, one of these arguments may be marked as a return value. Each argument should correspond to a state variable. Below is a listing with placeholders in *italics* for actual elements and values corresponding to a service description.

```
<?xml version="1.0"?>
<scpd xmlns="urn:schemas-upnp-org:service-1.0">
   <specVersion>
      <major>1</major>
      <minor>0</minor>
   </specVersion>
   <actionList>
      <action>
         <name>actionName</name>
         <argumentList>
            <argument>
               <name>formalParameterName</name>
               <direction>in xor out</direction>
               <retval />
               <relatedStateVariable>stateVariableName</
               relatedStateVariable>
            </argument>
            Declarations for other arguments defined by UPnP Forum
            working committee (if any) go here
         <argumentList>
      </action>
      Declarations for other arguments defined by UPnP Forum
      working committee (if any) go here
      Declarations for other actions added by UPnP vendor (if
      any) go here
   </actionList>
   <serviceStateTable>
      <stateVariable sendEvents="yes">
         <name>variableName</name>
         <dataType>variable data type</dataType>
         <defaultValue>default value</defaultValue>
         <allowedValueList>
            <allowedValue>enumerated value</allowed value>
            Other allowed values defined by UPnP Forum
            working committee (if any) go here
         </allowedValueList>
      <stateVariable>
      <stateVariable sendEvents="yes">
         <name>variableName</name>
         <dataType>variable data type</dataType>
         <defaultValue>default value</defaultValue>
```

```
            <allowedValueRange>
               <minimum>minimum value</minimum>
               <maximum>maximum value</maximum>
               <step>increment value</step>
            </allowedValueRange>
         </stateVariable>
         Declaration for other state variables by UPnP Forum working
         committee (if any) go here
         Declarations for other state variables added by UPnP vendor
         (if any) go here
      </serviceStateTable>
</scpd>
```

Further details of how to implement addressing, discovery and description under UPnP are available through well-publicized documentation, such as that available at the UPnP forum working committee web site (www.upnp.org) and Microsoft's UPnP web site (www.upnp.com).

At this point, the present invention departs from the standard techniques for controlling devices under UPnP, wherein interactions between devices are defined by generalized UPnP control and eventing protocols. Instead, the invention defines service-specific protocols to enable interaction between the extended PC and one or more remote devices that host the services used. In general, these services may include any service provided by a remote device, such as remote display, remote audio, remote input, and remote video; however, the invention is particularly advantageous when considering that in a typical implementation the majority of the hardware and software resources are hosted by the extended PC while the resources required for each remote device are typically "lightweight" in comparison.

Lightweight Remote Display Service

In accordance with one aspect of the invention, a protocol is provided that enables an extended PC to display content on a remote device using a "push" model, wherein the extended PC pushes data and control information to the remote device using a predefined set of commands, and the data is formatted to meet display capabilities advertised by the remote device via the discovery mechanism

discussed above. The service provides a simple TCP connection port on which the extended PC sends a stream of "display this picture at position X, Y" type commands

An exemplary set of protocol commands corresponding to a lightweight display service are shown below, with accompanying descriptions.

Reset(int ProtocolVersion):

This primitive is used by the extended PC to reset the display on the remote device. The display must clear itself and await instructions. This primitive also clears any state the remote device may have. The protocol is defined with minimal state, but reset is defined such as to future proof the device. If future protocol versions are defined, this command can be used to set which protocol version is going to be used by the extended PC.

Flush(int TimeSinceLastSync)

Some display devices may support double buffering, where the device writes images to a hidden buffer and only displays the hidden buffer to the screen when asked to do so. Double buffering results in less display flicker. The "TimeSinceLastSync" parameter specifies the number of refresh~~clock~~ cycles to wait before issuing the Flush command.

For example, suppose an NTSC TV adapter has double buffer support and it keeps track of the screen refresh (about 30 times per second). The device draws display data into its hidden buffer. When it receives a Flush(0) command, it displays the hidden buffer to the screen at the next screen refresh. If it is desired to animate a GIF at 15 frames per seconds, the extended PC will need to send an animation frame to the remote device followed by a Flush(2) command. This will instruct the device to wait 2 refresh cycles before executing the Flush command.

FlushFailed( )

This command allows the PC to kept track of the quality of the animated output and adjust it accordingly. If an animation frame is not received in time due to network and device loads, another mechanism comes into play to allow a PC to adaptively recover: If more than 2 refresh cycles occur before the reception of the Flush(2) command, a FlushFailed() command is returned to the PC. This allows the PC to adapt the frame rate and animation size to better fit the current network load and ability of the device.

DrawFillBox(x1, y1, x2, y2, Color)

Draw a fill box of the given color defined by the corner point (x1,y2) and (x2,y2).

DrawImage(x, y, image)

Draw an image at the (x,y) location. Here, the image can be in many different formats. When the PC discovers the remote device on the network, it will retrieve~~get~~ the screen size, color depth and supported image formats for the device's and/or the device service's description information. Information such as image width, height, and color are all encoded within the image format. The extended PC may use special features of some image types, such as alpha-blending and transparency, provided these capabilities are supported by the display device.

Allocate(Area Name, x, y, width, height) ~~**PlaceVideoBox**(x1, y1, x2, y2)~~

This command may be used in cases where a remote device supports streaming video as a separate service. This command allows the PC to place the video in a portion of the screen. Generally, the PC will set up the position of the video window using a configuration service or protocol, and start streaming

the video via a separate streaming service such as UPnP/AV as defined by the UPnP forum.

Repaint( )

On occasion a device may lose the_parts of the entire display content. To recover, the device can ask the extended PC to resend a complete update of the screen via the Repaint command.

Move(x1, y1, x2, y2, Width, Height)~~**Move**(Frame1, Frame2)~~

This command moves a block from a portion of the frame buffer identified by (X1, Y1, Width, Height)~~Frame 1~~ to another portion of the frame buffer identified by (X2, Y2, Width, Height). When using this command, devices may or may not support overlapping areas. If a device does not ~~Frame 2.~~

support this command at all, DrawImage commands are used instead.

In the most basic implementation, only Reset() and DrawImage() are required commands, while the remaining commands are optional. Perfectly synchronized animations can be played on a display device that supports the Flush() and FlushFailed() commands, since the device animates the frames based on its own clock. If these commands are not available, the extended PC can still push data and commands to perform an animation, but the quality of the animation is subject to network conditions.

An exemplary software/hardware architecture that enables an extended PC 38 to drive a display on a remote display device 128 is shown in FIGURE 9. As discussed above, the majority of the hardware and software resources used to implement the lightweight remote display resides on the extended PC. These include various software components 130, including a picture application 58, a UPnP device abstraction layer 62, a UPnP module 64, a display module 70, and a network module 72. Client-side software components 132, depicted as a

UPnP service module 40 and a display service module 48, enable network communication and remote display and synchronization to be performed by the remote display device in response to data and commands sent over a network communications link 134 via a network interface 136. In general, network interface 136 may comprise a network interface that supports one or more of the network interface protocols discussed above. Software components 132 will typically be stored as sets of machine instructions in a memory 140 that are executed by a controller 142 to perform the functions of each service. The remote display device also includes a display buffer 144~~buffer 140~~ that stores display data that is read by a display driver 146 to drive a display 148.~~driver 142 to drive a display 144.~~

Generally, controller 142~~controller 138~~ may comprise any component enabled to perform the lightweight remote display functions discussed above through execution of software components 132. For example, such components include various types of microprocessors and microcontrollers. Furthermore, memory 140 will typically comprise some form of non-volatile memory, such as ROM, EPROM, Flash memory, etc. In one embodiment, the operations performed by two or more of the hardware components may be provided by an Application Specific Integrated Circuit (ASIC)~~146~~ that is specifically designed to support the services provided by the remote display device.

As shown in FIGURE 9, remote display device 128 comprises an integrated device that includes both hardware and software components, as well as display 148. Optionally, the hardware and software components may be employed in a separate display adapter 150 that drives a display. For example, display 148 may comprise a television monitor 152 that receives input from a

display adapter. Optionally, display 148 may represent a digital picture frame 154 that is driven by a display adapter.

In most instances, the remote display device will be provided with data corresponding to a bitmap display. This enables the hardware on the display device to be minimized. However, since bitmaps take a large amount of memory and provide an inefficient means for storing image content, most image and video data are stored in some compressed format, such as JPEG and GIF for still images, and MPEG for video images. As a result, when using remote display devices that do not provide built-in decompression capabilities (either through built-in ~~in~~capabilities or provided via client-side software (e.g., display module 48), it will~~generally~~ be necessary to convert images from the compressed format into a bitmap format prior to sending the image data to the remote display device. Optionally, if the remote device supports image decompression (either through built-in hardware or the client side software), image data may be sent in a compressed format and decompressed at the remote display device. Compression, decompression, and sending these data are~~These operations may~~ be performed on extended PC 38 through execution of display module 70.

Remote Audio

In addition to driving still image and video displays, the present invention also supports remote audio capabilities. Typically, the UPnP description of an audio service will provide information pertaining to that device's audio capabilities, such as number of channels (i.e., speakers), playback rate, quality (e.g., number of bits), and supported~~supports~~ sound format (e.g., PCM), voice input, etc.

An exemplary architecture to enable an extended PC 38 to drive a remote audio device 156_and/or receive audio input from the remote audio device is shown in FIGURE 10. A number of software and hardware components used in this architecture are substantially similar to those discussed above with reference to FIGURE 9; these components share the same reference numbers in both Figures. A set of software components 158 are running on extended PC 38, including a jukebox application 60 and a sound module 66 in addition to UPnP device abstraction layer 62, UPnP module 64 and network module 72 discussed above. Remote audio device 156 includes an audio adapter 160 that includes software 162 stored in memory 140 that includes a sound service module 46. In addition to network interface 136 and controller 142, the remote audio device also includes an audio driver 164 that reads audio data stored in an audio buffer 166, and converts the audio data into an amplified audio signal that drives speakers 168.

In one embodiment, sound input services are additionally provided by remote audio device 156. In this instance, a user may provide verbal input via a microphone 165, which produces an analog audio signal that is received by an audio input block 167 and converted into audio data having a digital format. Optionally, microphone 165 may directly convert verbal input into the digitized audio data. In one embodiment, audio input block 167 will pass the digitized audio data to audio buffer 166, wherein it will be read by controller 142 and sent to extended PC 38 via network interface 136. Optionally, audio input block 167 may directly pass the digitized audio data to controller 142.

Typically, the user's verbal input will correspond to a set of command words (or a command language with a predefined syntax) that are used as verbal commands to control actions performed by extended PC 38.

Accordingly, sound module 66 will include voice recognition software that will be used to interpret the audio data it receives to determine what command(s) the verbal input corresponds to.

In one embodiment, a TCP socket is opened to the remote audio device (via a port number provided by the service's UPnP description). Both the device and the extended PC TCP sockets can be optionally configured to buffer only a small amount of data (depending on desired sound quality, network latency, and/or audio latency). The device simply reads PCM sound from the TCP socket and fills its audio buffer. If the remote sound device cannot perform these operations, it notifies the extended PC that there is a problem. In one embodiment, sound module 66~~display module 70~~ includes one or more functions that enable the extended PC to adapt the sound quality (defined by its outgoing audio data stream) to meet a remote sound device's playback capabilities in consideration of initial and/or changed network conditions. In one ~~conditions.~~

embodiment, the IETF defined RTP protocol (RTP: A Transport Protocol for Real-Time Applications, RFC1889, January 1996) is used to carry PCM encoded audio in real time.

Lightweight Remote Input Service

Devices that may implement the invention can be built using various types of input, from no input at all to pen-input, keyboard, mouse, and button input. Each type of input will generally be handled by a respective input service, wherein the existence and capabilities of each input service will be described in that service's UPnP description information. This information may include type of input device, commands supported (buttons, positions (e.g., pen, mouse position in XY coordinates), clicks, z-axis position), etc.).

Some devices, such as infrared remote controls, might require code running on the extended PC to interpret the time codes it receives from the remote control and convert them into button commands. In this instance, the corresponding UPnP service might also be used to advertise the presence of a custom input device and a URL link where the matching PC software required to support the device is located so that it can be downloaded to the extended PC over the Internet. Once downloaded, the extended PC can run the corresponding software component.

A basic set of primitives is supported by this lightweight remote input service. In one embodiment, these primatives include:

```
KeyDown(int keydata)
KeyPress(int keydata)
KeyUp(int keydata)
```

The three keyboard primitives match the well-known keyboard events used is almost all operating systems. KeyDown and KeyUp occur whenever a key is pushed or released, this generally includes all keys including control keys such as shift, ctrl, alt and function keys. The KeyPress event contains the resulting interpretation of the keystrokes such as small and large capitalization and keyboard repetitions.

```
MouseDown(int x, int y, int buttondata)
MouseMove(int x, int y, int buttondata)
MouseUp(int x, int y, int buttondata)
```

The three pointer primitives match the well-known keyboard events used is almost all operating systems. These primitives are not limited to mouse movements, any other pointing device such as trackballs, movement keys, pen input, touch sensitive screen and magnetic screens can also use them. During input service discovery, the extended PC is informed of the maximum values of x and y. If the device has a display, these pointer primitives may have a

different resolution that may not match the x and y of the display. In such instances, software residing on the extended PC may be used to scale the pointer position to the display.

RemoteControlKey(int buttondata)

The framework also supports a remote control primitive to send to applications button information that is not generally associated with a computer keyboard. These buttons include various buttons that are commonly found on remote control devices used to control audio and video equipment, such as VCRs, DVD players, CD players, jukeboxes, etc. Typically, these buttons will include: Play, Pause, Forward, Reverse, Next Track, VCR, DVD, CD, etc. In some~~Some~~ frameworks, the designer may opt to not use this primitive and map these remote control keys to standard computer keyboard events via custom software running on the remote device and/or the extended PC.

Custom(int channel_number, byte[] custom_data)

In general, all keyboard, mouse and possibly remote control primitives will be dispatched to applications as-is. For some devices, data processing will need to be performed before a keyboard or mouse event can be generated. In order to lower the cost of the device, it will be preferable that device use this custom primitive to send raw input data to the extended PC for interpretation. The extended PC then sends the raw data into the appropriate code module for interpretation; the code module will generally return mouse or keyboard primitives that can than by dispatched to the applications. In accordance with this primitive,~~primative,~~ each channel number can contain completely different raw data that may be sent to a different respective code module for interpretation.

In general, a remote device does not have to use all of these primitives, but rather can use all or a subset of them. Some devices may opt to use only custom data as input. An XML file will describe how the input service behaves, what primitive,~~primates~~ are used, data identifying the bounds of mouse coordinates, whether custom channels exist and where to obtain the code modules to interpret the raw input data. Preferably, the XML file will be written by the manufacturer of the device and validated using an XML-Schema file (XSD file). The Extended PC can also use the XSD file to validate the devices XML file before it is parsed.

Preferably, the code modules that are loaded and run by the extended PC should be authenticated, especially in instances in which code modules are downloaded from an Internet site. For example, authentication techniques such as digital signatures may be used to authenticate the code modules. Techniques for authentication are well-known in the art, and so no further details are provided herein. The code modules should also be designed to provide system safety. For instance, custom input code modules should be "sand-boxed" such that they are prevented from tampering with system files and other software on the extended PC.

Another instantiation of this remote input service would do a similar operation in reverse. A code module on the extended PC could be loaded to generate a custom command to a device. For example, if a device has an IR transmitter, the PC could load a code module that sends an array of IR pulse timings to the device to be used for re-transmission purposes.

An exemplary architecture illustrating host-side and client-side software and hardware components to enable an extended PC 38 to receive input from a remote device 170 is shown in FIGURE 11. As before, host-side software components include a UPnP device abstraction layer 62, a UPnP module 64

and a network module 72. New components that support remote device input services include an input module 68, a custom input module 172, an infra-red (IR) remote module 174, a touch display module 176, and a button map module 178.

In a typical implementation, input capabilities will be supported by an input adapter 180 provided for the remote device. The input adapter may comprise circuitry built into the remote device, or may comprise a separate add-on component. As with the display and audio adapters discussed above, the input adapter includes a network interface 136, a controller 142, and memory 140. In this instance, memory 140 includes software 182 comprising a UPnP client-side module 40 and a client-side input module 50. The input adapter further includes an input signal processing block 184, which may be performed by hardware and/or software components that are well-known in the art for processing signals from input devices. Optionally, the input adapter may also include an input buffer 186.

Generally, input adapter 180 will be designed to receive input from one or more input devices 188, which are exemplified by wired and wireless keyboards 190, wired and wireless pointing devices 192, and remote control devices 194.

An exemplary architecture provided by a PC/CE adapter 200 that implements a plurality of the services discussed above is shown in FIGURE 12. In this instance, the PC/CE adapter includes various software components that enable the adapter to interact with an extended PC 38, drive audio and video signals for a television (or television monitor) 202, drive a digital picture frame 204, and receive input from an IR remote control 206. These software components include a UPnP module 40, a sound service module 46, a display service module 48, and an input service

module 50. The sound and display service modules interact with appropriate hardware (not shown) to provide analog legacy audio and video signals 208 and 210 to a television 206. Also, digital audio and video signals may be sent using a 1394 link. Display service module 48 also is used to provide bitmap data to digital picture frame 204 via a~~wireless~~ IEEE 1394 connection 212. The PC/CE adapter is accessed via an IEEE 802.11a wireless connection 214 and provides a~~wireless~~ IEEE 1394 bridge 216 that enables IEEE 1394 signals to be interfaced with IEEE 802.11a signals.

Exemplary Computer System for Practicing the Invention

With reference to FIGURE 13, a generally conventional computer 300 is illustrated, which is suitable for use as the extended PC in connection with practicing the present invention, and may be used for running host-side software comprising one or more software modules that implement the various host-side functions of the invention discussed above. Examples of computers that may be suitable for hosts~~clients~~ as discussed above include PC-class systems operating the Windows XP, 2000, or NT~~NT or Windows 2000~~ operating systems, Sun workstations operating the UNIX-based Solaris operating system, and various computer architectures that implement LINUX operating systems. Computer 300 is also intended to encompass various server architectures, as well as computers having multiple processors.

Computer 300 includes a processor chassis 302 in which are mounted a floppy disk drive 304, a hard drive 306, a motherboard 308 populated with appropriate integrated circuits including memory 310 and one or more processors (CPUs) 312, and a power supply (not shown), as are generally well known to those of ordinary skill in the art. It will be understood that hard drive 106 may comprise a single unit, or multiple hard drives, and may optionally reside outside of

computer 300. A monitor 314 is included for displaying graphics and text generated by software programs and program modules that are run by the computer. A mouse 316 (or other pointing device) may be connected to a serial port (or to a bus port or USB port) on the rear of processor chassis 302, and signals from mouse 316 are conveyed to the motherboard to control a cursor on the display and to select text, menu options, and graphic components displayed on monitor 316 by software programs and modules executing on the computer. In addition, a keyboard 318 is coupled to the motherboard for user entry of text and commands that affect the running of software programs executing on the computer. Computer 300 also includes a network interface card 320 or~~of~~ built in network adapter for connecting the computer to a computer network, such as a local area network, wide area network, or the Internet.

Computer 300 may also optionally include a compact disk-read only memory (CD-ROM) drive 322 into which a CD-ROM disk may be inserted so that executable files and data on the disk can be read for transfer into the memory and/or into storage on hard drive 306 of computer 300. Other mass memory storage devices such as an optical recorded medium or DVD drive may be included. The machine instructions comprising the software that causes the CPU to implement the functions of the present invention that have been discussed above will likely be distributed on floppy disks or CD-ROMs (or other memory media) and stored in the hard drive until loaded into random access memory (RAM) for execution by the CPU. Optionally, all or a portion of the machine instructions may be loaded via a computer network.

Although the present invention has been described in connection with a preferred form of practicing it and modifications thereto, those of ordinary skill in the art will understand that many other modifications can be made to the invention within the scope of the claims that follow. Accordingly, it is not intended that the scope of

the invention in any way be limited by the above description, but instead be determined entirely by reference to the claims that follow.

CLAIMS

What is claimed is:

1. A method for controlling a remote device, comprising:

defining a service-specific protocol to facilitate remote control of a service provided by the remote device;

sending data corresponding to the service provided by the remote device via a host-side software module running on a host computer in a format defined by the service-specific protocol from the host computer to the remote device over a network communication link;

sending control commands from the host computer to the remote device based on the service-specific protocol to cause the remote device to perform the service using the data that are sent to the remote device.

2. The method of claim 1, wherein the network communication link is established by:

connecting the host computer to a network to which at least one remote device is already connected;

obtaining an IP address for the host computer;

broadcasting a search message over the network requesting that any device meeting a search criteria defined by data contained in the search message to contact the host computer using the IP address for the host computer;

listening for a response to the search message, and in response thereto:

retrieving a description of a service provided by a remote device that responds to the search message to obtain a port number that may be used to communicate with the service; and

opening a TCP (transmission control protocol) socket that uses the port number.

3. The method of claim 1, wherein the remote device comprises a display device and the service-specific protocol defines display commands that are used to display content on the display device by sending display commands and data pertaining to the display content from the host computer to the remote device over the network communication link.

4. The method of claim 1, wherein the remote device comprises an audio device and the service protocol includes audio commands that are used to playback audio content on the audio device by sending audio commands and audio data pertaining to the audio content from the host computer to the audio device over the network communication link.

5. The method of claim 1, wherein the service provided by the remote device comprises an input service and the service-specific protocol comprises an input protocol defining a plurality of input primitives, further comprising:

listening for input data from the remote device, wherein the input data has a format corresponds to said plurality of input primitives; and

interpreting the input data to generate input commands based on the input protocol.

6. A method for enabling interaction between a remote device and a host computer, comprising:

discovering a service provided by the remote device;

establishing a network communication link between the remote device and the host computer;

launching a host-side software module to run on the host computer to enable interaction with the service via a service protocol that is specific to the service and a client-side component running on the remote device;

sending data corresponding to the service from the host computer to the remote device over the network communication link;

sending commands from the host computer to the remote device based on the service protocol; and

performing service operations corresponding to the service with the remote device that employ the data sent to the remote device and are performed in response to the commands received from the host computer.

7. The method of claim 6, wherein the remote device comprises a display device and the service protocol defines display commands that are used to display content on the display device by sending display commands and data pertaining to the display content from the host computer to the remote device over the network communication link.

8. The method of claim 6, wherein the remote device comprises an audio device and the service protocol includes audio commands that are used to playback audio content on the audio device by sending audio commands and audio data pertaining

to the audio content from the host computer to the audio device over the network communication link.

9. The method of claim 6, wherein the service provided by the remote device comprises an input service and the service protocol includes input primitives to enable input data to be sent from the remote device to be interpreted by the host-side software module running on the host computer.

10. The method of claim 6, wherein establishing the network communication link comprises:

connecting the remote device to a network to which the host computer is already connected;

obtaining an IP address for the remote display device;

broadcasting information pertaining to the service provided by the remote device that includes a location from which a description of the service can be retrieved;

retrieving the description of the service to obtain a port number that may be used to communicate with the service; and

opening a TCP (transmission control protocol) socket that uses the port number.

11. The method of claim 10, wherein a DHCP (Dynamic host configuration protocol) host is connected to the network and obtaining an IP address comprise:

submitting a request from the remote device to the DHCP host for an IP address; and

allocating an IP address to the remote device via the DHCP host in response to the request.

12. The method of claim 10, wherein the remote display device obtains an IP address by performing the operations of:

automatically allocating itself an IP address selected from a pre-defined range of IP addresses;

verifying that the IP address that is automatically allocated is not used by any other device or host connected to the network, and

if the IP address is already in use, selecting another IP address and repeating the foregoing operations until a unique IP address for the network is obtained.

13. The method of claim 6, wherein establishing the network communication link comprises:

connecting the host computer to a network to which at least one remote device is already connected;

obtaining an IP address for the host computer;

broadcasting a search message over the network requesting that any device meeting a search criteria defined by data contained in the search message to contact the host computer using the IP address for the host computer;

retrieving a description of a service provided by a remote device that responded to the search message to obtain a port number that may be used to communicate with the service; and

opening a TCP (transmission control protocol) socket that uses the port number.

14. The method of claim 6, wherein discovering the service provided by the remote device comprises:

providing a network location from which a description of the service may be retrieved; and

retrieving the description of the service from the network location.

15. The method of claim 6, wherein the service protocol defines feedback primitives that are used to enable the remote device to send feedback data to the host computer.

16. A method for displaying content on a remote display device, comprising:

establishing a network communication link between the remote display device and a host computer;

determining display capabilities of the remote device;

sending display data corresponding to the display content from the host computer to the remote display device over the network communication link, said data having a format corresponding to display capabilities of the remote device;

sending display commands corresponding to a display service protocol indicating how the display data are to be displayed on the remote display device; and

displaying the display data on the remote display device in response to the display commands.

17. The method of claim 16, wherein the remote display device comprises a digital picture frame.

18. The method of claim 16, wherein the remote display device comprises a display adapter that provides signal to a television monitor.

19. The method of claim 16, wherein establishing the network communication link comprises:

connecting the remote display device to a network to which the host computer is already connected;

obtaining an IP address for the remote display device;

broadcasting information pertaining to at least one service provided by the remote display device that includes the IP address over the computer network; and

establishing a network communication link between the remote display device and the host of the remote display device that uses the IP address of the remote display device and an IP address previously assigned to the host computer.

20. The method of claim 16, wherein the display service protocol includes display synchronization commands that are sent to the remote device to enable the display content to refreshed in accordance with a predetermined timing to produce include synchronized animations.

21. The method of claim 16, wherein the display service protocol includes feedback primitives to enable the remote display device to provide display feedback information to the host computer.

22. A method for enabling a remote device to provide input to a host computer, comprising:

establishing a network communication link between the remote device and the host computer;

defining an input service protocol including a plurality of input primitives, each input primitive corresponding to a respective input event;

processing input events using an input service software module running on the remote device to produce input primitives corresponding to the input events;

sending the input primitives to the host computer; and

converting the input primitives into application inputs using a host-side input service module running on the host computer.

23. The method of claim 22, wherein the input events correspond to button activations resulting from a user pressing buttons on a remote control device linked in communication with the remote device.

24. The method of claim 22, wherein the input events correspond to keyboard button activations resulting from a user pressing buttons on a keyboard linked in communication with the remote device.

25. The method of claim 22, wherein the input events correspond to pointer device events resulting from a user activating a pointer device linked in communication with the remote device.

26. The method of claim 22, wherein the input primitives include a custom primitive that is used to pass raw input data received from an input device connected to the remote device to the host computer.

27. The method of claim 22, further comprising retrieving information corresponding to an input service provided by the remote device, said information including the primitives used by the input service.

28. The method of claim 27, wherein the information is stored in an XML (extended markup language) file that is retrieved by the host computer and parsed to determine the primitives used by the input service.

29. A method for enabling a remote device to provide input to a host computer, comprising:

establishing a network communication link between the remote device and the host computer;

defining an input service protocol including a plurality of verbal input commands, each input primitive corresponding to a respective input event;

in response to receiving verbal input at the remote device, generating digitized audio data corresponding to the verbal input commands;

sending the digitized audio data to the host computer via the network communication link;

processing the digitized audio data using speech recognition software running on the host computer to determine if the verbal input contains verbal input commands corresponding to the input service protocol; and

using such verbal input commands to control an action of the host computer.

30. The method of claim 29, further comprising storing the digitized audio data in a buffer on the remote device prior to sending it to host computer.

31. A machine-readable media on which a plurality of instructions are stored that when executed by the processor of a host computer perform the operations of:

interacting with a remote device to discover a service provided by the remote device;

interacting with the remote device to establish a network communication link between the remote device and the host computer;

sending data corresponding to the service from the host computer to the remote device over the network communication link;

sending commands from the host computer to the remote device over the network communication link based on a service protocol that is specific to the service provided by the remote device to cause the remote device to perform service operations specified by the commands that employ the data sent to the remote device.

32.~~30.~~ The machine-readable media of claim 31,~~29,~~ wherein establishing the network communication link comprises performing the operation of:

broadcasting a search message from the host computer over the network requesting that any device meeting a search criteria defined by data contained in the search message to contact the host computer using a network address assigned to the host computer;

retrieving a description of a service provided by a remote device that responds to the search message to obtain a port number that may be used to communicate with the service; and

opening a TCP (transmission control protocol) socket that uses the port number.

33.~~31.~~ The machine-readable media of claim 31,~~29,~~ wherein the remote device comprises a display device and the service protocol defines display commands that are used to display content on the display device by sending display commands and data pertaining to the display content from the host computer to the remote device over the network communication link.

34.~~32.~~ The machine-readable media of claim 31,~~29,~~ wherein the remote device comprises an audio device and the service protocol includes audio commands that are used to playback audio content on the audio device by sending audio commands and audio data pertaining to the audio content from the host computer to the audio device over the network communication link.

35.~~33.~~ The machine-readable media of claim 31,~~29,~~ wherein the service provided by the remote device comprises an input service and the service protocol includes input primitives to enable input data to be sent from the remote device to be interpreted by the host-side software module running on the host computer.

36.~~34.~~ A device comprising:

a network interface;

a memory in which a plurality of machine instructions are stored comprising a set of client-side software to control a service provided by the device in response to service protocol specific data and commands received by the device having a format defined by a protocol specific to the service; and

a controller, coupled to the network interface and the memory, to execute said plurality of machine instructions to perform the operations of:

interacting with a remote host computer to establish a network communication link via the network interface with the remote host computer; and

in response to receiving service protocol specific data and commands that are pushed to the device from the remote host computer over the network communications link, performing service operations specified by the commands that employ the data.

37.~~35.~~ The device of claim 36,~~34,~~ wherein the network communication link is established by performing the operations of:

broadcasting device identification and service information identifying a service provided by the device and a communications port via which other devices connected to the network including the remote host computer may communicate with the device;

opening a TCP/IP socket via the communications port.

38.~~36.~~ The device of claim 36,~~34,~~ wherein the device further includes a display coupled to the controller, and the service provided by the device comprises a display service that is driven by display commands defined by the service specific protocol to cause the device to display content on the display in response to receiving data and display commands from the remote host computer over the network communication link.

39.~~37.~~ The device of claim 36,~~34,~~ wherein the device comprises a display adapter that further includes an interface to couple to a display, and the service provided by the device comprises a display service that is driven by display

commands defined by the service specific protocol to cause the device send display content to the display in response to receiving data and display commands from the remote host computer over the network communication link.

40.~~38.~~ The device of claim 36,~~34,~~ further comprising an audio driver coupled to the controller and speakers, and wherein the service specific protocol includes audio commands that are used to cause the device to playback audio content in response to receiving audio commands and audio data pertaining to the audio content from the remote host computer over the network communication link.

41.~~39.~~ A device comprising:

a network interface;

a memory in which a plurality of machine instructions are stored including a set of client-side software to facilitate an input service provided by the device, said input service implemented through use of a input service protocol defining a set of input primitives;

an input signal processor to receive input signals from an input device; and

a controller, coupled to the network interface, the memory and the input signal processor, to execute said plurality of machine instructions to perform operations in combination with the input signal processor, including:

interacting with a remote host computer to establish a network communication link via the network interface with the remote host computer;

processing input signals received from an input device to generate input primitives corresponding to the input signals; and

sending the input primitives to the remote host computer via the network communication link.

~~40. The device of claim 39, wherein the input device comprises a keyboard.~~

~~41. The device of claim 39, wherein the input device comprises a pointer device.~~

42. The device of claim 41, wherein the input device comprises a keyboard.

43. The device of claim 41, wherein the input device comprises a pointer device.

44. The device of claim 41,~~39,~~ wherein the input device comprises a remote control.

ABSTRACT OF THE DISCLOSURE

A method and architecture for enabling interaction between a remote device and a host computer. A service provided by the remote device is discovered, and a description pertaining to the service is retrieved by the host computer. A network communication link is the established between the remote device and the host computer based on connection information provided by the description. Host-side and client-side software service modules are run on the host and remote devices to enable interaction between the devices using a service protocol that is specific to the service. Various service protocols are provided, including a display service protocol and an input service protocol. Using commands provided by each protocol, the host computer is enabled to control the service remotely by pushing data and appropriate commands to the remote device, whereupon these commands are processed by the client-side service module to perform service operations that employ the sent data.